APPENDIX J

GEOTECHNICAL INVESTIGATION
PROPOSED 26-INCH ROCKAWAY GAS PIPELINE
ROCKAWAY, QUEENS COUNTY, NY

GEOTECHNICAL INVESTIGATION
PROPOSED 26-INCH ROCKAWAY GAS PIPELINE
ROCKAWAY, QUEENS COUNTY, NY

Mustang Engineering, L.P.
16001 Park Ten Place
Houston, TX 77084

Mueser Rutledge Consulting Engineers
14 Penn Plaza – 225 West 34th Street
New York, NY 10122

November 12, 2009

Mueser Rutledge
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14 Penn Plaza · 225 West 34th Street · New York, NY 10122
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November 12, 2009

Mustang Engineering, L.P.
16001 Park Ten Place
Houston, TX 77084

Attention: Mr. Ron Gibbs

Re: Geotechnical Investigation
Proposed 26-inch Rockaway Gas Pipeline
Rockaway, Queens County, NY
Mustang Project No. 14174
MRCE File No. 11314

Dear Mr. Gibbs:

In accordance with our contract with Mustang Engineering, L.P. (MELP), Mueser Rutledge Consulting Engineers (MRCE) has completed a subsurface geotechnical investigation at the referenced site. This report summarizes the field and laboratory investigation performed and presents the data and results from the investigation.

1. EXHIBITS

The following exhibits are attached to this Report:

Figure No. 1	-	Site location Plan
Figure No. 2	-	Site History
Figure No. 3	-	General Geologic Formations
Drawing No. B-1	-	As-Drilled Boring Location Plan
Drawing No. GS-1	-	Geologic Profile A-A
Drawing No. GS-R	-	Geotechnical Reference Standards
Appendix A	-	Geotechnical Boring Logs
Appendix B	-	Gradation Plates
Appendix C	-	Direct Shear Testing Results
Appendix D	-	Electro-Chemical Testing Results

2. PROJECT DESCRIPTION

Mustang Engineering, LP (MELP) is designing a pipeline route for Transcontinental Gas Pipeline Company, LLC (TRANSCO) in Rockaway, Queens, NY. The proposed route is planned to expand gas supply service to existing customers from TRANSCO's existing pipeline systems as part of TRANSCO's Northeast Supply Expansion Project. The site location is shown on Plate No. 1.

The new 26-inch diameter gas pipeline would connect into the National Grid pipeline at Jacob Riis Park to the north and the existing sub-seabed TRANSCO 26-inch diameter pipeline in the Atlantic Ocean to the south. MELP engaged MRCE to perform a geotechnical investigation for the new pipeline segment proposed to be installed by Horizontal Directional Drilling (HDD) methods.

3. SUBSURFACE INVESTIGATION

MELP provided MRCE with a proposed boring layout for the geotechnical investigation. The investigation included 1 on-shore (land) boring (B-1) and 4 off-shore (water) borings (B-2 through B-5) at locations shown on Drawing No. B-1. MRCE sub-contracted with a boring contractor, Warren George, Inc. (WGI) of Jersey City, NJ to perform the field boring work and extract and provide MRCE with the soil samples from the borings.

The land boring was performed by WGI between August 26 through August 28, 2009 and was observed by Adam Dyer of MRCE, Robert Hotz of GeoEngineers Inc. (GEI) and Julie Rupp of Ecology and Environment, Inc. (ENE). The water borings were performed from September 1 through September 2 and from September 14 through 16, 2009. The water borings were observed by Jerry Chan and David Janke of MRCE and Webb Winston and Justin Brown of GE. ENE personnel, Gene Florentino and Julie Rupp, also observed Water Borings B-2 and B-4 (partial). ENE also collected portions of samples from the upper fill in Boring B-1 and the shallow sea bottom in Boring B-4 for environmental testing.

The Land Boring B-1 was made with a truck-mounted drill rig working during the day shift. It was staked out and surveyed by personnel from TRANSCO. The Water Borings B-2 through B-5 were made using a jack-up barge with the drill rig mounted on the barge platform, working 24 hours per day. The as-drilled locations of the water borings were obtained with GPS units by WGI and GEI and are shown on the Boring Location Plan on Drawing No. B-1.

In the land boring, a temporary steel casing was used to stabilize the borehole in the upper soils and a drilling additive, ZeoGel (attapulgite clay powder) was added to stabilize the remaining depth of the borehole. In the water borings also, a temporary steel casing was used to stabilize the shallow soils below the seafloor and the drilling additive used to stabilize the remaining depth of the borehole. In the water borings, the jack-up barge platform was the working surface and the sampling depths were referenced to the top of the platform. The MRCE inspectors periodically took depth measurements from the barge platform to the ocean surface and the ocean bottom and correlated them with the tide charts.

Soil samples were typically taken at five foot intervals. Soil samples were typically obtained with a standard two-inch O.D. split spoon sampler which is driven through four six-inch intervals with a 140-pound hammer free falling 30 inches (ASTM D1586). The Standard Penetration Test (SPT) was performed at each sample interval in which the number of blows required to drive the sampler through each of the four six-inch increments was recorded. The sum of the blows for the second and third six-inch intervals is defined as the SPT Resistance, or N-Value. The N-Value is an index of the in-situ density of the material and is reported in blows per foot (bpf). The sample is said to encounter refusal if the spoon cannot be driven at least six inches with 100 blows of the hammer. Occasionally, soils samples were collected at closer than five foot intervals for additional samples. Also, occasionally, a three-inch diameter split spoon sampler was used where a larger quantity of sample was required or to explore the gravel content in the soil. Detailed information regarding the drilling and sampling in each boring is provided in the individual boring logs attached in Appendix A to this Report.

As per MELP requirements, the borehole cuttings and drilling fluids were collected by WGI in 55-gallon drums and taken off-site for testing and disposal. Upon completion, the land boring was tremie-grouted with a cement-bentonite grout. The water borings filled-in with soil upon extraction of the temporary steel casing. Environmental contamination / characteristics of the soil or groundwater were not within the scope of MRCE investigation.

All soil samples were delivered by WGI to MRCE's soil mechanics laboratory in New York City. Samples were reviewed and field descriptions were revised as necessary for conformance with MRCE's Geotechnical Reference Standards, described on Drawing No. GS-R. Individual sample descriptions are based on the Unified Soil Classification System (USCS) and are provided in the boring logs in Appendix A.

4. LABORATORY TESTING

All soil samples recovered were primarily coarse grained (sand) soils. Besides the laboratory reclassification of all the soil samples, Mechanical Gradation tests (particle size analysis of soils per ASTM D422) were performed by MRCE on 58 samples selected as per MELP and GEI requirements. The results of the Gradation tests are shown on Plate Nos. 1 through 9 in Appendix B. For samples on which gradation tests were performed, the sample description and USCS symbol shown on the boring logs incorporated the results of the gradation tests.

Direct Shear tests (per ASTM 3080) were performed on a total of seven samples selected by GEI. The samples were consolidated under normal pressures representing the effective overburden pressures occurring in the field at the sample elevation. The results of these tests are provided in Appendix C.

As per MELP requirements, 33 selected samples were also tested for corrosivity (resistivity as per ASTM G57), pH (as per ASTM G51) and sulphate content (as per ASTM C1580). These tests were performed by a certified testing laboratory, SOR Testing Laboratories, Inc. (STL) of Cedar Grove, NJ under sub-contract to MRCE. The relevant soil samples were sent to STL laboratory by MRCE. The results of these electro-chemical tests are provided in Appendix D. STL also performed 1 Direct Shear test and 3 Gradation tests on samples sent to their laboratory due to limited sample present with MRCE. The results of these are included with the remaining Gradation tests and Direct Shear Tests in Appendix B and C respectively.

5. GENERAL GEOLOGIC CONDITIONS

5.1 SURFACE FEATURES

Rockaway Inlet provides access to Jamaica Bay, north of the Rockaway peninsula. The peninsula has changed significantly since the 1800s due to both natural processes and human intervention. The peninsula extended westwards by a few miles during this time period. The progression of growth of the western portion of the peninsula due to natural forces is shown on Figure No. 2. Additional bulkhead placement and filling has led to the current alignment along Rockaway inlet.

5.2 SITE GEOLOGY

The general site geology at the site is characterized by numerous glacial depositions overlying cretaceous deposits which lie above the deep bedrock surface. In the New York City area, the bedrock surface and the Coastal Plain sediments dip gradually to the southeast. A generalized geologic profile taken across the western edge of the Rockaway peninsula is shown on Figure No. 3.

Bedrock near the site is approximately at elevation El. -850 feet. Above the bedrock is the Cretaceous Lloyd Sand layer at approximately El. -650. The Raritan Clay member lies at about El. -485 and the Magothy layer around El. -250. During the relatively recent Pleistocene age, several glacial advances terminated in the region well north of the site, thereby depositing layers of outwash sand south of their terminal moraines, across the southern portion of Queens and Long Island. The oldest glacial deposit in the area is the Jameco Gravel, which is known to occur near the site at approximately El.-210. This was overlain by the interglacial Gardiners Clay, when temperatures increased and the glaciers melted, which is known to occur near the site at approximately El. -195. Above this elevation, outwash sands from the recent glaciations (10,000 to 30,000 years ago) were deposited.

At the end of the Pleistocene era, as the glaciers melted away, sea level started to rise. Wave action along the coast transported and reworked various glacial sediments into barrier islands. Over time, as sand was eroded from the ocean side and re-deposited across the barrier and into the bay, the islands migrated landward to their current positions, keeping pace with the sea level rise.

6. SUBSURFACE CONDITIONS

MRCE's interpretation of the subsurface conditions along the proposed pipeline alignment is illustrated in the form of Geologic Profile A-A on Drawing No. GS-1. All elevations are referenced to the Mean Lower Low Water (MLLW) Datum which at the site is 2.81 feet below the North American Vertical Datum (NAVD 1988). The horizontal and vertical scales are different in order to fit the paper size, therefore exaggerating the vertical profile of the features shown. The information shown for the borings on the profile include: Sample number and position, sampler penetration resistance (N-Value) and the USCS symbol for the soil samples. The boring legend and explanation of the USCS symbols are shown on Drawing No. GS-R.

The borings are projected onto the profile for clarity. The profile illustrates MRCE's interpretation of soil conditions, interpolating between and beyond the borings, and may or may not represent actual subsurface conditions. The subsurface stratigraphy encountered in the borings is described below in general order of their occurrence with increasing depth below ground surface.

Stratum F: Fill – This stratum was encountered only in the Land Boring B-1 for a depth of approximately 13.5 feet below ground surface. It can be generally described as medium to dense, brown, to gray-brown fine to medium sand with a trace of silt, shell fragments, coarse sand and glass fragments. This description is based on the soil samples obtained in the boring. Since this is an artificially placed soil layer, its description beyond the boring location may contain different materials of varying consistency and thickness. The N-Values in this stratum varied between 11 and 20 blows / per foot (bpf) with an average of 15 bpf.

Stratum S1: Sands – This natural sand stratum is believed to be of recent (Holocene) origin deposited after the glacial era. The soils of this stratum may be the reworked glacial sediments transported and re-deposited by wave action. It can be generally described as dense to very dense, gray to gray-brown fine to medium to coarse sand with a trace of silt, shells, gravel and mica. This stratum was found below the Fill in the land boring where it was approximately 35 feet thick. In the water borings, this stratum was found at the ocean bottom and extended to approximately El. -32 to El. -40. The N-Values in this stratum varied between 5 to 88 bpf with an average of 43 bpf. At the sea-bed there may be some debris at different locations. Evidence of debris of varying kind such as concrete and steel was noted in the MELP boring location plan based on a preliminary geophysical survey study. In the MRCE borings, such debris was not encountered at the sea-bed in any of the borings.

Stratum S2: Sands – This lower natural sand stratum is believed to be of glacial (Pleistocene) origin deposited as outwash sands south of the terminal moraines of the latest glacial advances. It generally consists of medium to very dense, brown to gray-brown fine to medium to coarse sand with a trace of silt, mica and occasionally trace shells, gravel and silt pockets. This stratum extended to the bottom depth of all the borings. At about El. -105 to El. -115, trace silt pockets were observed in the soil samples. Also around those elevations, some soil samples contained trace to some gravel and trace shells which may have caused the drill rig to chatter in two of the borings. This interface may indicate an interglacial re-working occurring between successive glacial advances. The N-Values in this stratum varied between 13 and 79 bpf with one N-Value of 111 bpf in Boring B-5 at El. -95. The average N-Value for this stratum was 39 bpf. The Direct Shear test samples selected by GEI were located at varying elevations within Stratum S2. The results are shown in Appendix C. The samples were formed in the test mold by compacting in their saturated condition to represent as close to their in-situ condition as possible with their water contents. The normal pressures applied on the test samples were approximately equal to their in-situ effective overburden pressures. The test results demonstrated peak effective friction angles varying from 31.3 degrees to 36.8 degrees and residual effective friction angles varying between 27 and 35.8 degrees. The soil gradation, degree of compaction in the laboratory at the saturated water content, normal pressures, sand grains orientation and mica content are known to have an influence on the friction angle.

Groundwater Level - The groundwater level (represented by the drilling fluid level) was observed overnight in the land boring. It was found to be at a depth of 6.5 feet below ground surface (El. +4.9). The groundwater is tidal in this area and will fluctuate with tidal wave action.

Electro-Chemical Test Results – The results of the electro-chemical tests are provided in Appendix D. The tests performed included soil resistivity, pH and sulphate content. The soil resistivity in the water boring samples varied between 84 and 190 ohms-cm indicative of a highly corrosive environment which would be expected for sands saturated with sea water. The land boring samples showed higher soil resistivity ranging from 210 to 850 ohms-cm (with one sample at 4600) which is indicative of a corrosive environment.

The pH in the water boring samples varied between 6.9 and 8.2 and in the land boring samples between 7.8 and 8.7. The sulphate content in the water boring samples varied between 0.030 and 0.118 and in the land boring samples between < 0.01 and 0.02.

Subsurface Conditions Pertaining to HDD – In general, stiff cohesive soils or sound bedrock conditions are ideal for HDD operations. Based on the HDD profile proposed for the pipeline by MELP, the soils that will be encountered along the drill path will primarily consist of fine to medium to coarse sands with a trace of silt, gravel, shells, mica. Some other materials may be encountered where the drill path will come close to the ground surface on land in the shallow fill soils. Debris may be present on the sea-bed which should be further investigated, especially in the vicinity of the HDD sea-bed exit point.

Since the subsurface soils are primarily sands with little fines and virtually no cohesion, the soils would be susceptible to cave-ins and running sand conditions. The selection of an appropriate drilling fluid will be critical in maintaining the stability of the HDD borehole. Maintenance of a continuous positive hydraulic head of slurry will also be critical for the HDD borehole stability. Since the groundwater is saltwater as opposed to freshwater, drilling fluid products which do not break down in saltwater environments would be required.

An experienced HDD engineer should evaluate the subsurface conditions presented in this report in order to perform a detailed feasibility study of the HDD methods for installing the proposed pipeline. An experienced HDD contractor should be engaged who can consider all the necessary aspects in detail, commensurate with similar past experience, in order to install the gas pipeline successfully.

If you have any questions on the above report, please contact us.

Very truly yours,

MUESER RUTLEDGE CONSULTING ENGINEERS

By: ______________________
Hiren J. Shah

By: ______________________
Hugh S. Lacy

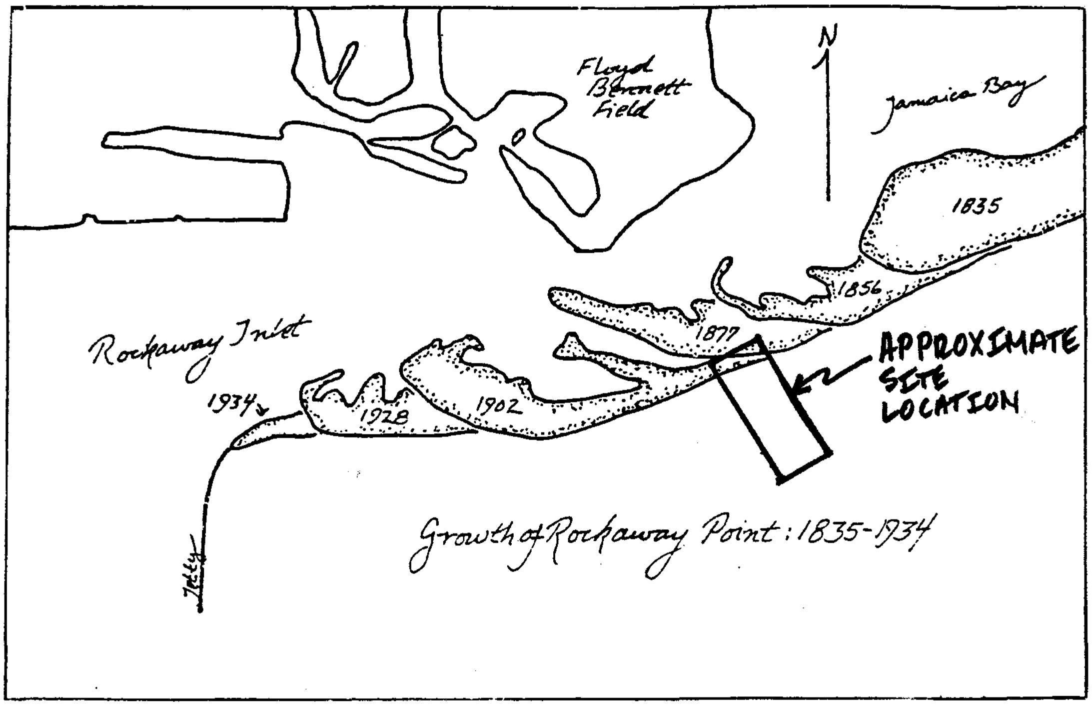
Attachments

HSL:HJS:SOHJ/bee/F:113/11314/Final Report

EXHIBITS

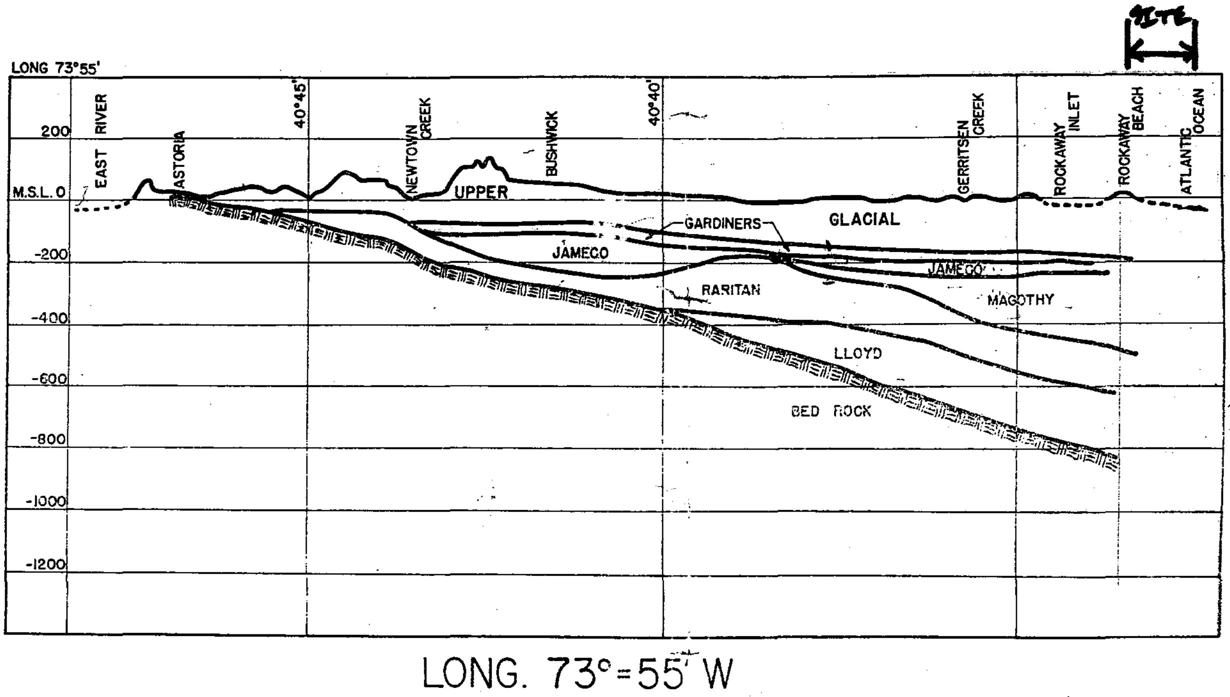
Source: Google Maps

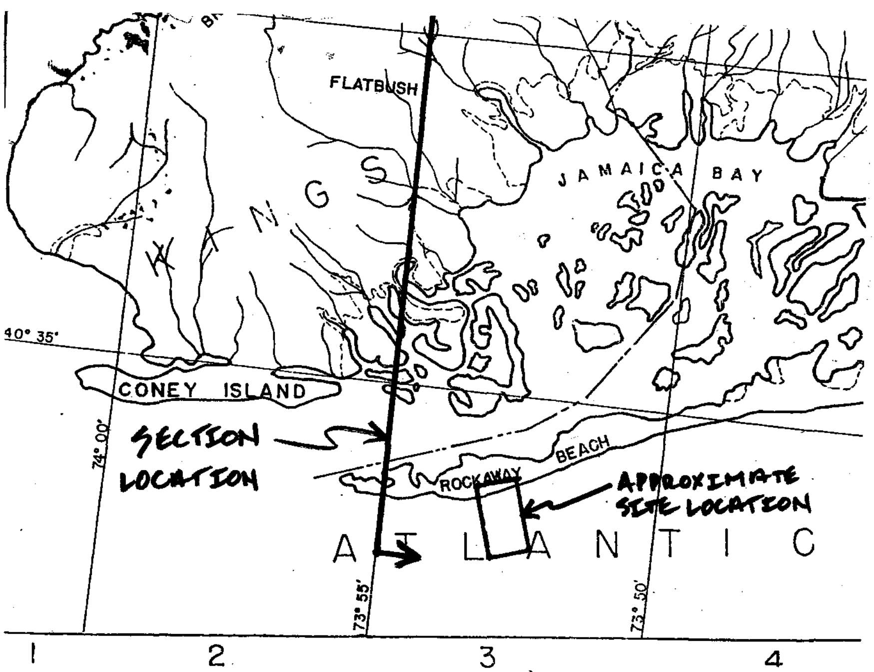
ROCKAWAY GAS PIPELINE QUEENS NEW YORK			
MUSTANG ENGINEERING HOUSTON TEXAS			
MUESER RUTLEDGE CONSULTING ENGINEERS 225 WEST 34TH STREET, NEW YORK, NY 10122			
SCALE --NA--	MADE BY: SOHJ CH'KD BY: HJS	DATE: 10-22-09 DATE: 10-22-09	FILE NO. 11314
SITE LOCATION			FIGURE NO. 1



Source: Kassner, J. & Black, J.; "Long Island's Western Beaches and Inlets"; Shore and Beach; pub. American Shore and Beach Preservation Association; July, 1984, pp. 12-16.

ROCKAWAY GAS PIPELINE QUEENS — NEW YORK			
MUSTANG ENGINEERING HOUSTON — TEXAS			
MUESER RUTLEDGE CONSULTING ENGINEERS 225 WEST 34TH STREET, NEW YORK, NY 10122			
SCALE --NA--	MADE BY: SOHJ CH'KD BY: HJS	DATE: 10-22-09 DATE: 10-22-09	FILE NO. 11314
SITE HISTORY			FIGURE NO. 2





Source: ed. Suter, R.; Geol. Data by de LaGuna, W. & Perlmutter, N. M.; Bulletin GW-18, Mapping of Geologic Formations and Aquifers of Long Island, New York; State of New York, Department of Conservation, Water Power and Control Commission; Albany, NY; 1949.

ROCKAWAY GAS PIPELINE

QUEENS NEW YORK

MUSTANG ENGINEERING

HOUSTON TEXAS

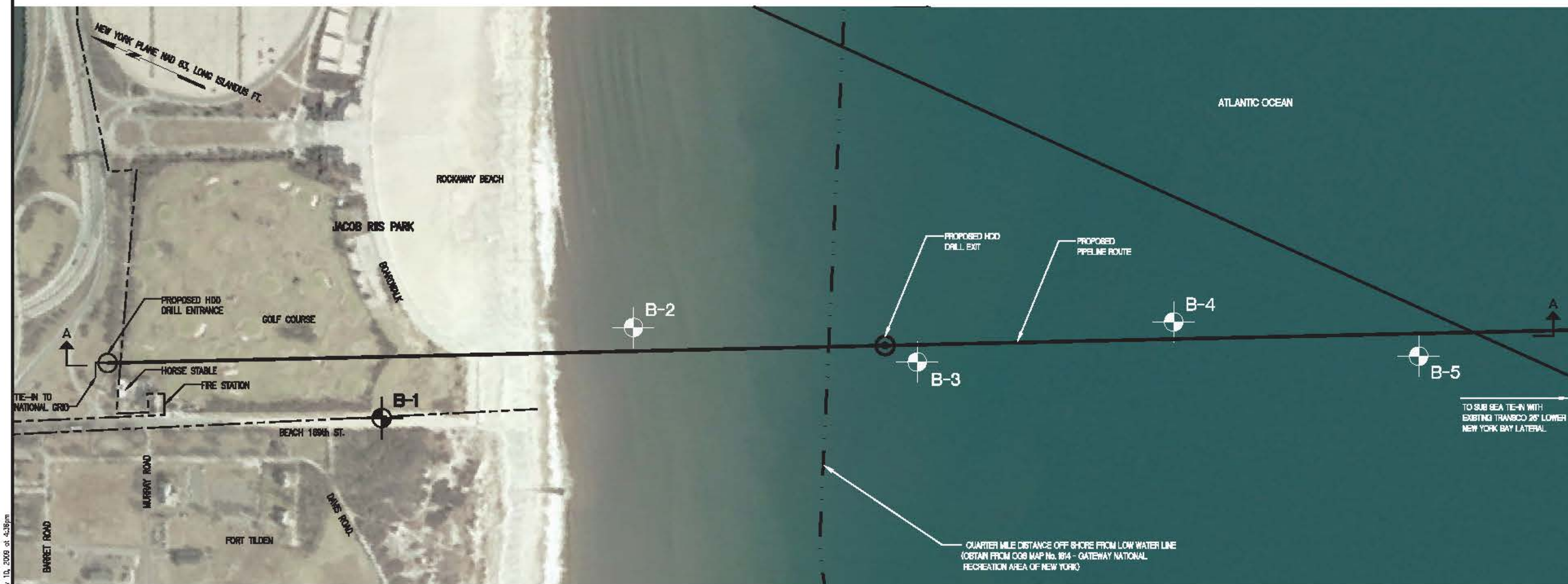
MUESER RUTLEDGE CONSULTING ENGINEERS

225 WEST 34TH STREET, NEW YORK, NY 10122

SCALE	MADE BY: SOHJ	DATE: 10-22-09	FILE NO.
--NA--	CH'KD BY: HJS	DATE: 10-22-09	11314

GENERAL GEOLOGIC FORMATIONS

FIGURE NO. 3



PLAN
SCALE: 1"=200'-0"

LEGEND:

B-1 — AS-DRILLED BORING LOCATION. BORING DRILLED BY WARREN GEORGE INC. IN AUGUST-SEPTEMBER 2009 UNDER THE CONTINUOUS INSPECTION OF MUESER RUTLEDGE CONSULTING ENGINEERS.

NOTES:

1. BASE PLAN FOR THIS DRAWING PROVIDED BY MUSTANG ENGINEERING, L.P. (MELP).
2. AS-DRILLED CO-ORDINATES OF THE BORINGS ARE SHOWN IN THE TABLE ON THIS DRAWING.
3. ALL ELEVATIONS ARE REFERENCED TO THE MEAN LOWER LOW WATER (MLLW) DATUM WHICH AT THE SITE IS 2.61 FEET BELOW THE NORTH AMERICAN VERTICAL DATUM (NAVD 1988) PER SURVEY INFORMATION PROVIDED BY MELP.
4. THE LAND BORING B-1 WAS MADE USING A TRUCK-MOUNTED DRILL RIG. THE MARINE BORINGS WERE MADE WITH A JACK-UP BARGE MOUNTED DRILL RIG. ALL BORINGS WERE MADE USING MUD ROTARY DRILLING METHODS. CASING AND DRILLING FLUIDS WERE USED TO MAINTAIN A STABLE BOREHOLE. SOIL SAMPLES WERE COLLECTED USING A SPLIT-SPOON SAMPLER (TYPICALLY 2-INCH O.D. AND OCCASSIONALLY 3-INCH O.D. AS REQUIRED). THE SAMPLER WAS ADVANCED USING A 140-POUND HAMMER FALLING 30-INCHES. FOR ADDITIONAL DETAILS REFER TO THE BORING LOGS ATTACHED TO THE REPORT.
5. FOR GEOLOGIC PROFILE A-A, REFER TO DRAWING NO. GS-1.

ROCKAWAY DELIVERY LATERAL HDD CROSSING

AS-DRILLED BORE HOLE LOCATION COORDINATES

BORING NO.	GEOGRAPHIC		STATE PLANE-NY LONG ISLAND	
	LATITUDE	LONGITUDE	NORTHING	EASTING
B-1	–	–	144633.00	1017484.70
B-2	40°33'41.124"	73°52'39.848"	143841.668	1018237.480
B-3	40°33'30.087"	73°52'35.280"	142725.384	1018576.186
B-4	40°33'21.285"	73°52'27.854"	141533.704	1019148.335
B-5	40°33'11.665"	73°52'24.329"	140862.285	1019424.146

GRAPHIC SCALE
200' 100' 0 200' 400'

ROCKAWAY GAS PIPELINE
QUEENS NEW YORK

MUSTANG ENGINEERING
HOUSTON TEXAS

MUESER RUTLEDGE CONSULTING ENGINEERS
14 PENN PLAZA – 225 W. 34TH STREET, NY, NY 10122

SCALE	MADE BY A.P./B.B.	DATE 10-19-09	FILE NO.
AS NOTED	CH'KD BY H.J.S.	DATE 10-26-09	11314

AS-DRILLED BORING LOCATION PLAN — DRAWING NO. B-1

Nov 10, 2009 at 4:36pm
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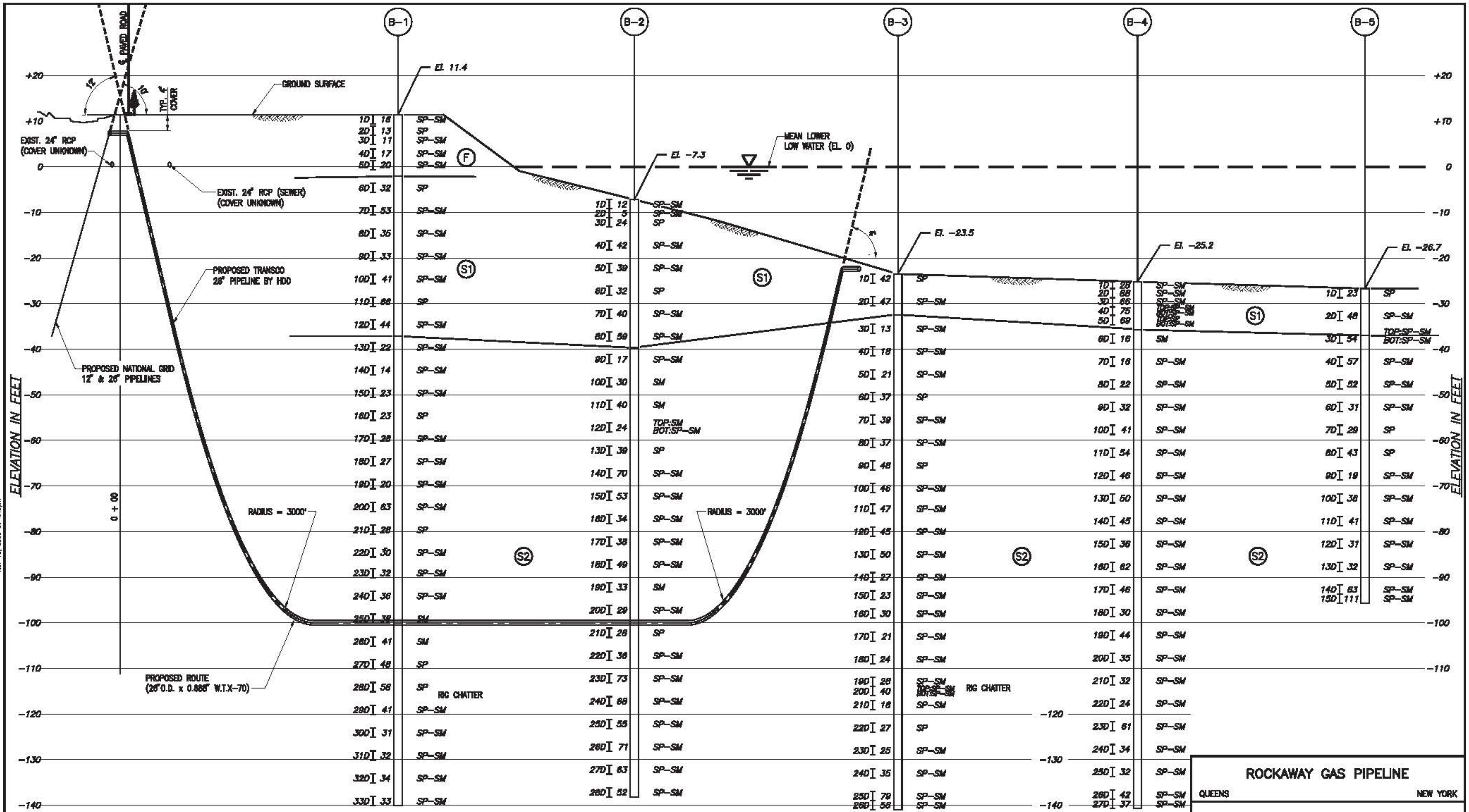
echerkasskaya



GEOLOGIC PROFILE A-A

GENERAL STRATA DESCRIPTIONS:

F **STRATUM F:** MEDIUM TO DENSE, BROWN TO GRAY-BROWN FINE TO MEDIUM SAND, TRACE SILT, SHELL FRAGMENTS, COARSE SAND, GLASS.

S1 **STRATUM S1:** DENSE TO VERY DENSE, GRAY TO GRAY-BROWN FINE TO MEDIUM TO COARSE SAND, TRACE SILT, SHELLS, GRAVEL, MICA.

S2 **STRATUM S2:** MEDIUM TO VERY DENSE, BROWN TO GRAY-BROWN FINE TO FINE TO MEDIUM TO COARSE SAND, TRACE, SHELLS, MICA, OCCASIONAL TRACE SILT POCKETS, SILT, GRAVEL.

NOTES:

1. FOR GENERAL NOTES REFER TO DRAWING NO. B-1.
2. HDD PROFILE SHOWN ON THIS DRAWING PROVIDED BY MUSTANG ENGINEERING, L.P. (MELP).
3. FOR BORING AND GEOLOGIC PROFILE LOCATIONS, REFER TO DRAWING NO. B-1.
4. FOR BORING LEGEND, REFER TO DRAWING NO. GS-R.
5. VERTICAL AND HORIZONTAL SCALES ON THIS DRAWING ARE DIFFERENT - SEE GRAPHIC SCALE.
6. GROUND SURFACE ELEVATION OF LAND BORING B-1 ALSO REFERENCED TO THE MEAN LOWER LOW WATER (MLLW) DATUM. AT THE SITE, MLLW DATUM IS 2.61 FEET BELOW THE NORTH AMERICAN VERTICAL DATUM (NAVD 1988).
7. BORINGS SHOWN ON THE GEOLOGIC PROFILE ARE PROJECTED ONTO THE PROFILE.
8. STRATIFICATIONS AND OCEAN BOTTOM SHOWN BETWEEN BORINGS ARE INTERPOLATIONS AND MAY OR MAY NOT REFLECT ACTUAL SUBSURFACE CONDITIONS.

GRAPHIC SCALE

HORIZ. 200' 100' 0 200' 400'

VERT. 10' 5' 0 10' 20'

ROCKAWAY GAS PIPELINE	
QUEENS	NEW YORK
MUSTANG ENGINEERING	
HOUSTON	TEXAS
MUESER RUTLEDGE CONSULTING ENGINEERS 14 PENN PLAZA - 225 W. 34TH STREET, NY, NY 10122	
SCALE: GRAPHIC	MADE BY A.P. DATE 10-20-09 / CH'KD BY H.J.S. DATE 10-23-09
FILE NO. 11314	
GEOLOGIC PROFILE A-A	DRAWING NO. GS-1

Nov 10, 2009 at 4:10pm

G:\DWGS\113\11314\GS-1.dwg

echarkasskaya

UNIFIED SOIL CLASSIFICATION (INCLUDING IDENTIFICATION AND DESCRIPTION)

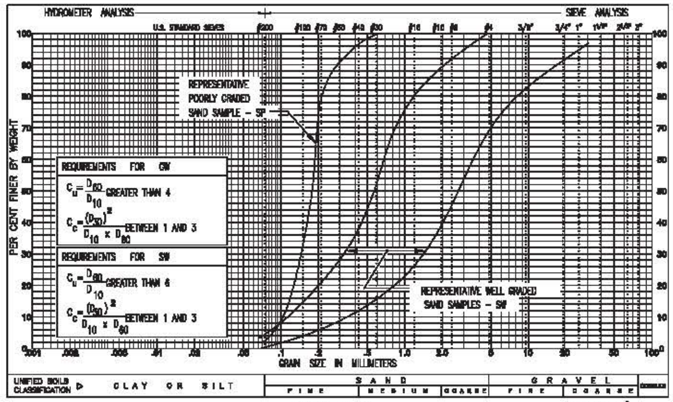
MAJOR DIVISIONS 1	MAJOR DIVISIONS 2		GROUP SYMBOLS 3	TYPICAL NAMES 4	FIELD IDENTIFICATION PROCEDURES (EXCLUDING PARTICLES LARGER THAN 3 IN. AND BASING FRACTIONS ON ESTIMATED WEIGHTS) 5
COARSE-GRAINED SOILS MORE THAN HALF OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVELS MORE THAN HALF OF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE SIZE	CLEAN GRAVELS (LITTLE OR NO FINES)	GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.	WIDE RANGE IN GRAIN SIZES AND SUBSTANTIAL AMOUNTS OF ALL INTERMEDIATE PARTICLE SIZES.
			GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.	PREDOMINANTLY ONE SIZE OR A RANGE OF SIZES WITH SOME INTERMEDIATE SIZES MISSING.
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	GM	SILTY GRAVELS, GRAVEL-SAND-SILT-MIXTURES.	NONPLASTIC FINES OR FINES WITH LOW PLASTICITY (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES.	PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)
	(FOR VISUAL CLASSIFICATION, THE 1/4 -IN. SIZE MAY BE USED AS EQUIVALENT TO THE NO. 4 SIEVE SIZE)				
	SANDS MORE THAN HALF OF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE SIZE	CLEAN SANDS (LITTLE OR NO FINES)	SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES.	WIDE RANGE IN GRAIN SIZES AND SUBSTANTIAL AMOUNTS OF ALL INTERMEDIATE PARTICLE SIZES.
			SP	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES.	PREDOMINANTLY ONE SIZE OR A RANGE OF SIZES WITH SOME INTERMEDIATE SIZES MISSING.
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	SM	SILTY SANDS, SAND-SILT-MIXTURES.	NONPLASTIC FINES OR FINES WITH LOW PLASTICITY (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)
			SC	CLAYEY SANDS, SAND-CLAY MIXTURES.	PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)

THE NO. 200 SIEVE SIZE IS ABOUT THE SMALLEST PARTICLE VISIBLE TO THE NAKED EYE

MAJOR DIVISIONS 1	MAJOR DIVISIONS 2	GROUP SYMBOLS 3	TYPICAL NAMES 4	IDENTIFICATION PROCEDURES ON FRACTION SMALLER THAN NO. 40 SIEVE SIZE: DRY STRENGTH (CRUSHING CHARACTERISTICS)	DILATANCY (REACTION TO SHAKING)	TOUGHNESS (CONSISTENCY NEAR PL)
FINE-GRAINED SOILS MORE THAN HALF OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS LIQUID LIMIT IS LESS THAN 50	ML	INORGANIC SILTS, SANDY SILTS, ROCK FLOUR, OR CLAYEY SILTS WITH SLIGHT PLASTICITY.	NONE TO SLIGHT	QUICK TO SLOW	NONE
		CL	INORGANIC CLAYS, OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS.	MEDIUM TO HIGH	NONE TO VERY SLOW	MEDIUM
		OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY.	SLIGHT TO MEDIUM	SLOW	SLIGHT
	SILTS AND CLAYS LIQUID LIMIT IS GREATER THAN 50	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS.	SLIGHT TO MEDIUM	SLOW TO NONE	SLIGHT TO MEDIUM
		CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS.	HIGH TO VERY HIGH	NONE	HIGH
		OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS.	MEDIUM TO HIGH	NONE TO VERY SLOW	SLIGHT TO MEDIUM
HIGHLY ORGANIC SOILS		Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS.	READILY IDENTIFIED BY COLOR, ODOR, SPONGY FEEL AND FREQUENTLY BY FIBROUS TEXTURE.		

BOUNDARY CLASSIFICATIONS: SOILS POSSESSING CHARACTERISTICS OF TWO GROUPS ARE DESIGNATED BY COMBINATIONS OF GROUP SYMBOLS, I.E: SP-SC POORLY GRADED SAND WITH CLAY BINDER.

LABORATORY CLASSIFICATION CRITERIA

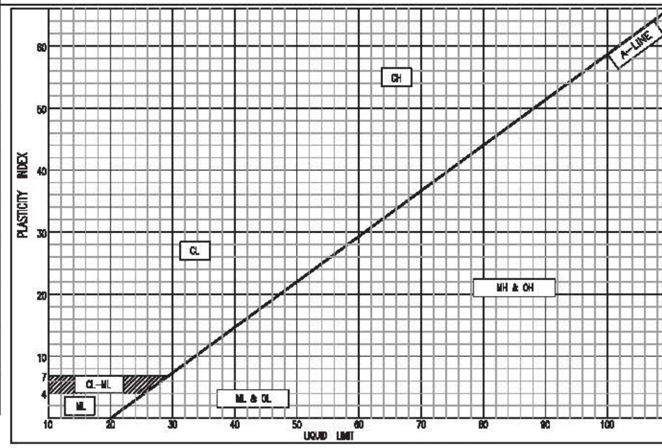


GRAIN SIZE PLOT

COBBLE 3-12"
BOULDER > 12"

DEPENDING ON PERCENTAGE OF FINES (FRACTION SMALLER THAN NO. 200 SIEVE SIZE) COARSE GRAINED SOILS ARE CLASSIFIED AS FOLLOWS:

LESS THAN 5%	GW, GP, SW, SP
MORE THAN 12%	GM, GC, SM, SC
5% TO 12%	BORDERLINE CASES REQUIRING USE OF DUAL SYMBOLS, I.E.: SP-SM, GP-GM



PLASTICITY CHART FOR CLASSIFICATION OF FINE GRAINED SOILS

TERMINOLOGY USED IN MRCE SOIL DESCRIPTIONS

DEGREE OF COMPACTION FOR NON-PLASTIC SOIL

DEGREE OF COMPACTION	BLOWS* PER FOOT
LOOSE	0 TO 10
MEDIUM COMPACT	11 TO 29
COMPACT	30 TO 50
VERY COMPACT	GREATER THAN 50

* STANDARD PENETRATION RESISTANCE USING 140 LB. HAMMER FREE FALLING 30 INCHES TO DRIVE A 2 INCH O.D. SPLIT-SPOON SAMPLER.

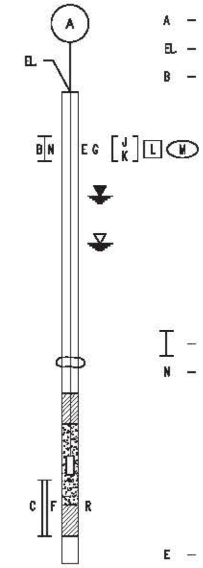
CONSISTENCY OF CLAY AND CLAYEY SILT+

CONSISTENCY	UNCONFINED COMPRESSIVE STRENGTH (TSF)	IDENTIFICATION CHARACTERISTICS
SOFT	LESS THAN 0.5	EASILY REMOLDED WITH SLIGHT FINGER PRESSURE
MEDIUM	0.5 TO 1.0	REQUIRES SUBSTANTIAL PRESSURE FOR REMOLDING
STIFF	1.0 TO 4.0	DIFFICULT TO REMOLD WITH FINGERS
HARD	GREATER THAN 4.0	CANNOT BE REMOLDED WITH FINGERS

+ NONPLASTIC SILTS ARE DESCRIBED USING DEGREE OF COMPACTION AS PRESENTED FOR NON-PLASTIC SOIL.

DESCRIPTION OF CONSTITUENT PERCENTAGES AS USED IN SOIL SAMPLE CLASSIFICATIONS

1% TO 12% – "TRACE"
13% TO 30% – "SOME"
31% TO 49% – ADJECTIVE FORM OF SOIL GROUP (EG. SANDY)
EQUAL AMOUNT – "AND" (EG. SAND AND GRAVEL)



BORING LEGEND

A – NUMBER, TYPE AND LOCATION OF BORING

EL. – GROUND SURFACE ELEVATION AT BORING

B – NUMBER AND TYPE OF SAMPLE

- D – DRY SAMPLE TAKEN WITH 2 INCH O.D. SPLIT SPOON
- U – UNDISTURBED SAMPLE TAKEN WITH 3 INCH O.D. FIXED PISTON TYPE SAMPLER
- UO – UNDISTURBED SAMPLE EXTRUDED IN FIELD AND PLACED IN JAR DUE TO POOR RECOVERY OR DISTURBANCE
- S – THIN TUBE SAMPLE TAKEN WITH SHELBY TUBE SAMPLER
- W – WASH SAMPLE
- NR – NO RECOVERY

I – LENGTH OF SAMPLE ATTEMPT

N – STANDARD PENETRATION RESISTANCE. NUMBER OF BLOWS FROM 140 LB. HAMMER FREE FALLING 30 INCHES REQUIRED TO DRIVE 2 INCH O.D. SPLIT SPOON SAMPLER ONE FOOT AFTER INITIAL PENETRATION OF 6 INCHES, UNLESS A SPECIFIC PENETRATION IS INDICATED.

- P – PRESSED OR PUSH SAMPLE
- WH – SAMPLE TAKEN UNDER WEIGHT OF HAMMER AND RODS
- WR – SAMPLE TAKEN UNDER WEIGHT OF RODS

E – AVERAGE NATURAL WATER CONTENT OF SAMPLE, IN PERCENT OF DRY WEIGHT

G – UNIFIED SOIL CLASSIFICATON GROUP SYMBOL OF SAMPLE

[J] = ATTERBERG LIQUID LIMIT VALUE
[K] = ATTERBERG PLASTIC LIMIT VALUE

L – COMPRESSIVE STRENGTH IN TSF DETERMINED FROM UNCONFINED COMPRESSION TEST

M – COMPRESSIVE STRENGTH IN TSF DETERMINED FROM UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST

– GROUNDWATER LEVEL OBSERVED IN BORING
*– MUD LEVEL

– GROUNDWATER LEVEL OBSERVED IN PIEZOMETER

C – ROCK CORE NUMBER

– LENGTH OF CORE RUN

F – LENGTH OF CORE RECOVERED EXPRESSED AS A PERCENT OF THE LENGTH OF CORE RUN

R – ROCK QUALITY DESIGNATION–THE SUM OF THE LENGTHS OF PIECES OF RECOVERED CORE WHICH ARE EQUAL TO OR GREATER THAN FOUR INCHES IN LENGTH, EXPRESSED AS A PERCENTAGE OF THE TOTAL LENGTH OF CORE RUN. LENGTHS ARE MEASURED BETWEEN IN-SITU SEPARATIONS AND MECHANICAL BREAKS RESULTING FROM CORING ARE IGNORED.

IMPERVIOUS SEAL

SAND FILTER SURROUNDING PIEZOMETER INTAKE ELEMENT

INTAKE ELEMENT

COBBLE OR BOULDER

MUESER RUTLEDGE CONSULTING ENGINEERS
225 WEST 34th STREET – 14 PENN PLAZA
NEW YORK, NY 10122

GEOTECHNICAL REFERENCE STANDARDS

DRAWING NO. GS-R

The appendices/attachments to this document are available for viewing on the FERC website (http://www.ferc.gov). Using the "eLibrary" link, select "General Search" from the eLibrary menu, enter the selected date range and Docket No. CP13-36 (Transco's application), and follow the instructions. For assistance, please call 1-866-208-3676, or e-mail FERCOnlineSupport@ferc.gov.